Estimating and analysing the cost efficiency of Greek cooperative banks: an application of two-stage data envelopment analysis

Fotios Pasiouras, Emmanouil Sifodaskalakis & Constantin Zopounidis
University of Bath
School of Management
Working Paper Series
2007.12

University of Bath School of Management
Working Paper Series

School of Management
Claverton Down
Bath
BA2 7AY
United Kingdom
Tel: +44 1225 826742
Fax: +44 1225 826473
http://www.bath.ac.uk/management/research/papers.htm

2007		
2007.01	Fotios Pasiouras	International evidence on the impact of regulations and supervision on banks' technical efficiency: an application of two-stage data envelopment analysis
2007.02	Richard Fairchild	Audit Tenure, Report Qualification, and Fraud
2007.03	Robert Heath & Paul Feldwick	50 Years using the wrong model of TV advertising
2007.04	Stephan C. Henneberg, Daniel Rohrmus & Carla Ramos	Sense-making and Cognition in Business Networks: Conceptualisation and Propositional Development
2007.05	Fotios Pasiouras, Sailesh Tanna & Constantin Zopounidis	Regulations, supervision and banks' cost and profit efficiency around the world: a stochastic frontier approach
2007.06	Johan Lindeque, Mark Lund & Steven McGuire	Non-Market Strategies, Corporate Political Activity and Organizational Social Capital: The US Anti-Dumping and Countervailing Duty Process
2007.07	Robert Heath	Emotional Persuasion in Advertising: A Hierarchy-of-Processing Model
2007.08	Joyce Yi-Hui Lee & Niki Panteli	A Framework for understanding Conflicts in Global Virtual Alliances
2007.09	Robert Heath	How do we predict advertising attention and engagement?

2007.10	Patchareeporn Pluempavarn & Niki Panteli	The Creation of Social Identity Through Weblogging
2007.11	Richard Fairchild	Managerial Overconfidence, Agency Problems, Financing Decisions and Firm Performance.
2007.12	Fotios Pasiouras, Emmanouil Sifodaskalakis & Constantin Zopounidis	Estimating and analysing the cost efficiency of Greek cooperative banks: an application of two-stage data envelopment analysis

Estimating and analysing the cost efficiency of Greek cooperative banks: an application of two-stage data envelopment analysis

Fotios Pasiouras[1], Emmanouil Sifodaskalakis[2], Constantin Zopounidis[3*]

[1]School of Management, University of Bath, Bath, UK

[2] Corporate Banking Division, Eurobank EFG, Athens, Greece

[3]Financial Engineering Laboratory, Department of Production Engineering and Management, Technical University of Crete, University Campus, Chania, 73100, Greece

Abstract

We follow a two-stage procedure to examine for the first time the cost efficiency of Greek cooperative banks. Our sample consists of 16 banks over the period 2000-2004. We first use data envelopment analysis (DEA) to estimate the technical, allocative and cost efficiency for each bank in sample. Then, we use Tobit regression to determine the impact of internal and external factors on banks' efficiency. The results of DEA indicate that Greek cooperative banks could improve their cost efficiency by 17.7% on average as well as that the dominant source of cost inefficiency is allocative rather than technical. The results of Tobit regression indicate that size has a positive impact on all measures of efficiency. However, the impact of capitalization, branches and ATMs depends on the efficiency measure and whether we control for market conditions or not. GDP per capita has a negative and significant impact on all measures of efficiency, while unemployment rate has also a negative and significant impact on technical and cost efficiency although not on allocative efficiency. Finally, banks operating in regions with higher disposal income of households in relation to the total disposal income of households in Greece are more efficient in terms of allocative and cost efficiency.

Keyword: Banking, Cooperative, Data envelopment analysis, Efficiency, Tobit Regression

JEL: G21, C24, C67, D61

May 2007

 E-mails: f.pasiouras@bath.ac.uk (F. Pasiouras), manos_sifo@hotmail.com (E. Sifodaskalakis), kostas@dpem.tuc.gr (C. Zopounidis).

1. Introduction

Over the last years, several papers have examined the efficiency of banks using either parametric (e.g. stochastic frontier analysis, thick frontier approach, distribution free approach) or non-parametric (e.g. data envelopment analysis-DEA) techniques[1]. However, most of these studies focus on commercial banks, while considerably less studies examine the efficiency of cooperative banks (e.g. Molyneux and Williams, 2005; Bos and Kool, 2006) or consider them in comparisons with other types of banks (e.g. Girardone et al., 2006). Some of the studies that examine cooperative banks focus on individual countries such as U.S. (Rezvanian et al., 1996), Netherlands (Bos and Kool, 2006), Italy (Altunbas et al., 1994), Finland (Kolari and Zardkoohi, 1990), and Germany (Lang and Welzel, 1996), while others consider various EU countries (e.g. Molyneux and Williams, 2005; Cavallo and Rossi, 2002; Weill, 2004; Girardone et al., 2006).

The purpose of the present paper is to provide additional evidence by examining the Greek cooperative banking sector. Our study has two overall objectives. The first is the estimation of the cost efficiency of Greek cooperative banks. To the best of our knowledge, this is the first study that undertakes such an analysis in Greece, in contrast to previous studies that focus on commercial banks (e.g. Karafolas and Mantakas, 1996; Noulas, 1997, 2001; Christopoulos and Tsionas, 2001; Christopoulos et al., 2002; Tsionas et al., 2003; Halkos and Salamouris, 2004; Apergis and Rezitis, 2004; Kamberoglou et al., 2004; Rezitis, 2006; Pasiouras, 2006). Furthermore, the previously mentioned studies, which examine various EU cooperative banking sectors (e.g. Girardone et al., 2006), have traditionally excluded Greek banks, due to difficulties in collecting data which are not available in commercial databases such as Bankscope.

Our second objective lies on the investigation of the factors that have an impact on the efficiency of Greek cooperative banks. We consider several external and internal factors as explanatory variables. External factors are market-specific and reflect various aspects such as the economic well-being of the residents, unemployment, and investments. Since the banks in the sample operate in 16 prefectures from 11 regions, local market economic conditions might have an impact on their cost efficiency. In a similar manner, the importance of considering

[1] Berger and Humphrey (1997) and Goddard et al. (2001) provide key discussions and comparison of these methods.

environmental variables during the estimation of efficiency has been recognized in early cross-country studies (e.g. Dietsch and Lozano-Vivas, 2000; Lozano-Vivas et al., 2002) and examined in most of the recent cross-country studies (e.g. Hauner, 2005; Fries and Taci, 2005; Pasiouras, 2007). However, to the best of our knowledge, only Bos and Kool (2006) have examined the impact of local market conditions on the efficiency of cooperative banks, while focusing on Netherlands. Internal factors correspond to both financial and non-financial bank-specific characteristics.

Our study is particularly important because, despite their relatively small market share in comparison to commercial banks, Greek cooperative banks play an important role in the development of the local economy. They mainly focus on small and medium enterprises (SMEs) and private citizens, provide support, and encourage the development of local enterprises. By offering competitive banking products adjusted to local conditions and with operational features, they attempt to be established as reliable, friendly, and flexible. Hence, the level of their efficiency and the analysis of its determinants can be of special interest to several stakeholders such as customers-members, bank managers, local community, and of course bank regulators.

The rest of the paper is structure as follows. Section 2 provides a brief note on the Greek cooperative banking sector. Section 3 describes the data and methodology, while Section 4 discusses the empirical results. The conclusions are presented in Section 5.

2. A brief note on the Greek cooperative banking sector

The Greek cooperative banking industry has a history of approximately ten years. While a few institutions were established earlier[2], they were operating as credit cooperatives until the early 1990s when they obtained a licence to operate as cooperative banks. More precisely, according to the regulations, credit cooperatives that raise the minimum capital required and fulfil certain condition can apply and obtain the permit from the Bank of Greece to operate as credit institutions, allowing them to offer all banking activities like any commercial bank within the borders of the

[2] The Co-operative Bank of Lamia launched its activities as the Credit Co-operative of "Technicians of Lamia" in 1990, which makes it the oldest existing Co-operative in Greece. It evolved into a Credit Institution in 1993. The Co-operative Bank of Ioannina was initially founded in 1978 as a Credit Co-operative under the name of "Development Co-operation of the Prefecture of Ioannina". It evolved into a Credit Institution in 1993 (Association of Greek Cooperative Banks, 2005).

area in which they are activated. Those credit cooperatives that obtain a licence to operate as credit institutions do not alter their legal status and can make use of the term "Cooperative Bank"[3].

Currently, there are 16 cooperative banks operating in Greece with a total network of 126 branches, offering their services in the largest part of the country. From the above-mentioned banks, two are qualified to operate all over the country while another four have reached the required cooperative capital allowing them to extent their operations in the neighbouring regions. There are also sixteen credit cooperatives, which have not yet fulfil the requirements that will allow them to operate as cooperative banks, and their services are limited in grating loans or providing other financial facilities to their members.

[Insert Table 1 Around Here]

Although cooperative banks have experienced a small increase in their market share over the last years, they still hold a relatively small amount of total assets in the Greek banking sector that at the end of 2005 was equal to 0.8% (Table 1). Nevertheless, despite the competition that they face, cooperative banks have demonstrated an improvement in most financial aspects over the last years. As Table 2 indicates, between 2000 and 2004, net profit before taxes increased by 19.29%, assets by 30.61%, and deposits by 40.91%. Furthermore, over the same period branches increased by 16.67%, while personnel and members experienced an increase around 11.5%.

[Insert Table 2 Around Here]

3. Methodology and data

3.1 The two step approach

Our analysis consists of two steps. First, we use DEA to measure the technical, allocative and cost efficiency of cooperative banks in Greece during 2000-2005. Then, the efficiency scores from step one are regressed on external and internal

[3] The operation of Greek cooperative banks is governed by law 2076/92, which incorporated into Greek Law the European Union's Directive 77/78 that defines the structure and operation of Credit Institutions, as well as Act. No 2258/2.11.1993, promulgated under the hands of the Governor of the Bank of Greece.

factors using Tobit regression as in Rezitis (2006), Havrylchyk (2006), Isik and Hassan (2003), Pasiouras (2006, 2007) among others. Pastor (2002) points out the following advantages of this procedure: (i) easy implementation, (ii) possibility of considering many environmental variables simultaneously, without increasing the number of efficient units, (iii) no need to know the orientation of the influence of each environmental variable, (iv) possibility of use when some (or all) of the environmental variables are common to sub-sets of individuals.

DEA is a mathematical programming approach for the development of production frontiers and the measurement of efficiency relative to the developed frontiers (Charnes et al., 1978). One of its well-known advantages, which is particularly relevant to our study, is that DEA works well with small samples. As Maudos et al. (2002) point out, "*Of all the techniques for measuring efficiency, the one that requires the smallest number of observations is the non-parametric and deterministic DEA, as parametric techniques specify a large number of parameters, making it necessary to have available a large number of observations*." (p. 511). Another advantage of DEA is that there is no need to specify a particular functional form for the production frontier.

To discuss DEA in more technical terms, let us assume that there data on K inputs and M outputs on each of N DMUs (i.e. banks). For the *i*-th bank these are represented by the vectors x_i and y_i, respectively. The $K \times N$ input matrix, X, and the $M \times N$ output matrix, Y, represent the data for all N banks. According to Charnes et al. (1978) the input oriented measure of a particular bank, under constant return to scales[4] (CRS), is calculated as:

[4]Banker et al. (1984) suggested the use of variable returns to scale (VRS) that decomposes technical efficiency under CRS (TE-CRS) into a product of two components. The first is technical efficiency under VRS also known as pure technical efficiency (PTE) and the second is scale efficiency (SE) that refers to exploiting scale economies. The technical efficiency scores obtained under VRS are higher than or equal to those obtained under CRS and SE can be obtained by dividing TE-CRS with PTE. While several recent studies perform the analysis under VRS, others argue in favour of CRS rather than VRS. For example, Noulas (1997) points out that the assumption of CRS allows the comparison between small and large banks. In a sample where a few large banks are present, the use of VRS framework raises the possibility that these large banks will appear as being efficient for the simple reason that there are no truly efficient banks (Berg et al., 1991). Avkiran (1999) also mentions that under VRS each unit is compared only against other units of similar size, instead of against all units. Hence, the assumption of VRS is more suitable for large samples. Soteriou and Zenios (1999) argue that caution is necessary when using the VRS formulation. First, because the model orientation (i.e. input minimization or output maximization) becomes important. Second, because the use of weights restriction in the VRS assessment may lead to some other problematic results (Allen, 1997). On the basis of these arguments, we estimate our model under the assumption of CRS as Avkiran (1999), Noulas (1997, 2001), Ariff and Can (2007) among others.

$$
\begin{aligned}
& Min_{\theta,\lambda}\theta \\
& \text{s.t. } -y_i + Y\lambda \geq 0 \\
& \theta x_i - X\lambda \geq 0 \\
& \lambda \geq 0
\end{aligned}
$$

where $\theta \leq 1$ is the scalar efficient score and λ is $\mathrm{N} \times 1$ vector of constants. If $\theta = 1$ the bank is efficient as it lies on the frontier, whereas if $\theta \prec 1$ the bank is inefficient and needs a $1-\theta$ reduction in the inputs levels to reach the frontier. The linear programming is being solved N times, once for each bank in sample, and a value of θ is obtained for each bank representing its technical efficiency (TE) score.

Then, in order to calculate allocative efficiency (AE), we assume that w_i is a $\mathrm{N} \times 1$ vector of input prices for the *i*-th bank and solve the following cost minimization DEA:

$$
\begin{aligned}
& \min_{\lambda, xi*} w_i' x_i^* \\
& \text{st} \quad -y_i + Y\lambda \geq 0 \\
& x_i^* + X\lambda \geq 0 \\
& \lambda \geq 0
\end{aligned}
$$

where x_i^* (which is calculated by the LP) is the cost-minimizing vector of input quantities for the *i*-th bank, given the input prices w_i and the output levels y_i. The total cost efficiency (CE) of the i-th bank is calculated as

$$CE = w_i' x_i^* / w_i' x_i$$

That is, CE is the ratio of minimum cost to observed cost, for the i-th bank. The (input-mix) allocative efficiency (AE) is calculated as AE = CE/TE. All three measures can take values between 0 and 1 with higher values indicating higher efficiency.

3.2. Variables

The first step in measuring efficiency using DEA is to specify the inputs and outputs of banks. As in most recent studies (e.g. Casu and Molyneux, 2003; Isik and Hassan, 2003; Pasiouras, 2007) we adopt the intermediation approach, which assumes that banks act as financial intermediates that collect purchased funds and use labour capital to transform these funds to loans and other assets. The three inputs are: fixed assets (X_1), deposits (X_2) and number of employees (X_3). The two outputs are: loans (Y_1), and liquid assets & investments (Y_2). The input prices are calculated as: depreciation expenses to fixed assets (P1), interest expenses to deposits (P2) and personnel expenses to number of employees (P3).

As mentioned earlier, in the second stage of the analysis we examine the impact of bank-specific factors and local market conditions on bank's efficiency. In particular we use two financial[5] and two non-financial bank-specific characteristics. SIZE measured by the logarithm of total assets is a proxy for size; EQAS calculated as equity capital to total assets is a measure of capital strength; ATMs and BRANCHES correspond to the number of ATMs and branches respectively. They both indicate the easy to access to the services of banks and potentially capture strategic decisions of bank management. For instance, in those regions in which the population density is low, banks might need an extensive network of branch offices to meet customer demand. However, extensive network will result in higher overheads and therefore lower cost efficiency. Hence, a high number of ATMs might be an alternative way to offer part of banks' services at a lower cost.

In an attempt to capture the impact of local market conditions on efficiency, we use four variables in total. GDPCAP is the GDP per capita; UNEMPL is the unemployment rate; INCOME corresponds to the disposal income of households[6] in

---

[5] Obviously several additional financial variables could be used. However, we avoid including variables that contain elements such as loans and deposits, that have been used as inputs/outputs in the first stage of the analysis to minimize potential heterogeneity concerns.

[6] Disposal income of households corresponds to the primary and secondary of households. It is calculated as: operating surplus and mixed income + compensation of employees (received) + property income (received) - property income (paid) + social benefits other than social benefits in kind

the region as a percentage of the total disposal income of households in Greece; INVGDP shows the total gross fixed capital formation (ie. new investments in fixed capital assets) as a percentage of GDP in the same geographical area.

3.3. Data

Our initial sample consists of all 16 Greek cooperative banks[7] over the period 2000-2004. However, the sample size varies by year due to data availability or zero values in the case of inputs/outputs[8]. The sample size per year is as follows: 14 (2000), 14 (2001), 14 (2002), 15 (2003), 16 (2004). The financial data were extracted from income and balance sheet statements. Additional information for the number of ATMs, and the number of branches was collected either from the annual reports or were provided by the Association of Cooperative Banks of Greece (ACBG). Finally, data related to market conditions were obtained from the General Secretariat of National Statistical Service of Greece. With respect to the later, due to data availability only GDP per capita corresponds to the prefecture in which banks are headquartered and operate (e.g. Chania, Heraklion, etc). In all other cases (e.g. UNEMPL, INCOME), we use data for the general region (e.g. Crete) following the classifications of General Secretariat of National Statistical Service of Greece. Table 3 presents descriptive statistics (mean and standard deviation). Panel A shows data used in the first stage of the analysis (i.e. DEA), while Panel B reports data used in the second stage[9] (i.e. Tobit regression).

[Insert Table 3 Around Here]

(received) + other current transfers (received) - current taxes on income wealth (paid) - social contribution (paid) - other current transfers (paid).

[7] While our sample appears small in absolute terms, it is comparable to previous studies that examine efficiency in the Greek commercial banking sector as well as in other countries. For example, Apergis and Rezitis (2004) and Rezitis (2006) examine six banks, Karafolas and Mantakas (1996) examine eleven banks, while the sample in Pasiouras (2006) ranges between twelve and eighteen banks. Several studies outside Greece have also used relatively small samples, including the study of Chu and Lim (1998) that examines as few as six banks, Drake (2001) that examines only nine UK banks and Neal (2004) that examines twelve Australian banks. After all, as mentioned in section 3.1 one of the most well known advantages of DEA is that it works well with small samples.

[8] The first year for which data were available for Cooperative Bank of Serres is 2004. As for banks with zero values in inputs/outputs these were excluded from the analysis in the respective years, because DEAP 2.1. (Coelli, 1996) cannot deal with zero and negative values.

[9]At this point, we should mention that that we have smoothed all independent variables by replacing observations above the 95th percentile and below the 5th percentile with the corresponding values. This approach reduces the impact of outliers in the estimation of the parameters of the model while it allows retaining all observatories in sample.

4. Results

As in Isik and Hassan (2002) among others, we estimate separate annual efficiency frontiers rather than a common frontier across time. Isik and Hassan (2002) point out the following two advantages of this approach. First, it is more flexible and thus more appropriate than estimating a single multiyear frontier for the banks in the sample. Second, it alleviates, at least to an extent, the problems related to the lack of random error in DEA by allowing an efficient bank in one year to be inefficient in another, under the assumption that the errors owing to luck or data problems are not consistent over time.

Table 4 presents the average efficiency scores by year. The overall (cost) efficiency score ranges between 0.802 (2004) and 0.836 (2002) with an average equal to 0.823 over the period of our analysis. Thus, Greek cooperative banks could improve their cost efficiency by 17.7% on average or in other words, banks could have used only 82.3% of the resources actually employed (i.e. inputs) to produce the same level of outputs. In each year, allocative inefficiency is always higher than technical inefficiency, suggesting that the dominant source of cost inefficiency of Greek cooperative banks is allocative rather than technical. On average, banks in sample could improve technical efficiency by 7.9% and allocative efficiency by 10.9%. This implies that the managers of banks were relatively good at using the minimum level of inputs at a given level of outputs but they were not that good at selecting the optimal mix of inputs given the prices.

[Insert Table 4 Around Here]

In order to investigate the determinants of efficiency we construct an econometric model with TE, AE and CE as dependent variables. As in previous studies, due to the limited nature of our efficiency measures (i.e. range between 0 and 1) we use Tobit analysis. As Saxonhouse (1976) points out, heteroscedacity can emerge when estimated parameters are used as dependent variables in the second stage analysis. Thus, following Hauner (2005) and Pasiouras (2006, 2007), QML (Huber/White) standard errors and covariates are calculated. Panel A in Table 5 shows the regression results when we consider only bank-specific attributes as independent variables. Panel B presents the results when both the bank-specific attributes and the variables that proxy for market conditions enter the equation.

[Insert Table 5 Around Here]

EQAS is statistically significant and positive related to TE, indicating that well-capitalized cooperative banks are more technically efficient that is consistent with the results of previous studies (e.g. Isik and Hassan, 2003). However, the insignificant impact of EQAS on AE and CE indicates that the capitalization of banks does not influence their allocative and cost efficiency. LOGAS is statistically significant and positive related to all measures of efficiency. Hauner (2005) offers two potential explanations for which size could have a positive impact on cost efficiency. First, if it relates positively to market power, large banks should pay less for their inputs. Second, there might be increasing returns to scale through the allocation of fixed costs (e.g. for research or risk management) over a higher volume of services or from efficiency gains from a higher specialized workforce. The results also indicate that banks with a broader ATM network appear to be more efficient (in terms of TE and CE), whereas more branches reduce efficiency (TE and CE) that is consistent with the results of Bos and Cool (2006) in Netherlands. However, the impact of both ATM and BRANCHES on CE disappears when we control for market conditions.

GDPCAP has a negative and statistically significant impact on all measures of efficiency, however the value of the coefficient is relatively small in all cases. INVDP is also negatively related to efficiency although insignificant in all cases. To some extend these results might be related to the findings of previous studies which report that in high growth and investment regions cost efficiency is relatively low (Maudos et al., 2002; Bos and Kool, 2006). Maudos et al. (2002) argue that under expansive demand conditions banks feel less pressure to control their costs and are therefore less cost efficient. However, in our case we also find that as the disposal income of households in the region relative to the total disposal income of households in Greece increases, allocative and cost efficiency also increase. Finally, we find that lower unemployment rate results in higher technical and cost efficiency.

5. Conclusions

Over the last years, Greek cooperative banks, which have a history of approximately ten years, have demonstrated an improvement in most financial aspects along with an increase in branches, personnel and members. Despite their importance for the local markets and enterprises, they have received significantly less attention than commercial banks. Hence, in the present study, we followed a two-stage procedure and examined for the first time the efficiency of the Greek cooperative banking sector.

Our sample consisted of the population of cooperative banks, a total of 16 banks, operating in Greece over the period 2000-2004. We first use data envelopment analysis to estimate the efficient frontiers and determine the efficiency score for each bank in sample. We found that Greek cooperative banks could improve their cost efficiency by 17.7% on average or in other words they could have used only 82.3% of the resources actually employed (i.e. inputs) to produce the same level of outputs. We also found that allocative inefficiency was always higher than technical inefficiency. Thus, the managers of banks were relatively good at using the minimum level of inputs at a given level of outputs but they were not that good at selecting the optimal mix of inputs given the prices.

In the second stage of our analysis, we used Tobit regression to determine the internal and external factors that had an impact on banks' technical, allocative, and cost efficiency. We found that well-capitalized cooperative banks were more technically efficient although capitalization was not related to allocative and cost efficiency. Larger banks were more technical, allocative and cost efficient ones. Banks with a broader ATM network and less branches appeared to be more technical and cost efficient, however the impact of both ATMs and branches on cost efficiency disappeared when we controlled for market conditions.

With respect to the local market conditions, GDP per capita had a negative and statistically significant impact on all measures of efficiency; however, the value of the coefficient was relatively small in all cases. Unemployment rate also had a negative and significant impact on technical and cost efficiency. Finally, banks operating in regions with higher disposal income of households in relation to the total disposal income of households in Greece, were more efficient in terms of allocative and cost efficiency.

Future work could extend our research in various directions not considered in this study. First, the efficiency of cooperative banks could be compared with that of commercial banks. Second, subject to data availability over a longer period that would result in a higher sample, one could estimate cost and profit efficiency using stochastic frontier analysis.

Acknowledgements

We would like to thank the Association of Co-operative Banks of Greece for providing us data for cooperative banks and the General Secretariat of National Statistical Service of Greece, and in particular Ms. Elisavet Vrontou from the Division of Statistical Information for her prompt replies with respect to our requests for information for the Greek regions and prefectures. We would also like to thank Prof. Coelli from the Centre for Efficiency and Productivity Analysis (University of Queensland) for making DEAP 2.1. publicly available free of charge. The views and conclusions presented in the paper are exclusively those of the authors and not necessarily reflect the position of Eurobank EFG or any other person associated with Eurobank EFG.

References

Allen R. Incorporating value judgements in data envelopment analysis. PhD Dissertation, Warwick Business School, University of Warwick, UK; 1997.

Altunbas Y, Molyneux P, Di Salvo R. Inefficiency in the Italian credit cooperative bank sector- A stochastic frontier analysis, Unpublished working paper, Institute of European Finance; 1994.

Apergis N, Rezitis A. Cost Structure, Technological Change, and Productivity Growth in the Greek Banking Sector. International Advances in Economic Research 2004; 10; 1-15.

Ariff M, Can L. Cost and profit efficiency of chinese banks: A non-parametric analysis. China Economic Review 2007; In press, doi: 10.1016/j.chieco.2007.04.001.

Association of Greek Cooperative Banks. Time Series Developments of Financial Data of the Group of Cooperative Banks 2000-2004. available at: http://www.este.gr/index.asp; 2005.

Avkiran N.K. The evidence on efficiency gains: The role of mergers and the benefits to the public. Journal of Banking and Finance 1991; 23; 991-1013.

Bank of Greece. Annual Report 2004. Athens, Available at: http://www.bankofgreece.gr/en/publications/report.asp.

Bank of Greece. Annual Report 2005. Athens, Available at: http://www.bankofgreece.gr/en/publications/report.asp.

Banker R.D, Charnes A, Cooper W.W. Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. Management Science 1984; 30; 1078-1092.

Berg S.A, Forsund F, Jansen E. Technical efficiency of Norwegian banks: a nonparametric approach to efficiency measurement. Journal of Productivity Analysis 1991; 2; 127-142.

Berger A.N, Humphrey D.B. Efficiency of financial institutions International survey and directions for future research, European Journal of Operational Research 1997; 98; 175-212.

Bos J.W.B, Kool C.J.M. Bank efficiency: The role of bank strategy and local market conditions. Journal of Banking & Finance 2006; 30; 1953-1974.

Casu B, Molyneux P. A comparative study of efficiency in European banking. Applied Economics 2003; 35; 1865-1876.

Cavallo L, Rossi S.P.S. Do environmental variables affect the performance and technical efficiency of the European banking systems? A parametric analysis using the stochastic frontier approach. The European Journal of Finance 2002; 8; 123-146.

Charnes A, Cooper W.W, Rhoads E. Measuring the efficiency of decision making units. European Journal of Operational Research 1978; 2; 429-444.

Christopoulos D.K, Lolos S.E.G, Tsionas E.G. Efficiency of the Greek banking system in view of the EMU: a heteroscedastic stochastic frontier approach. Journal of Policy Modeling 2002; 24; 813-829.

Christopoulos D.K, Tsionas E.G. Banking economic efficiency in the deregulation period: results from heteroscedastic stochastic frontier models. The Manchester School 2001; 69; 656-676.

Chu S.F, Lim G.H. Share performance and profit efficiency of banks in an oligopolistic market: evidence from Singapore, Journal of Multinational Financial Management 1998; 8; 155-168.

Dietsch M, Lozano-Vivas A. How the environment determines banking efficiency: A comparison between French and Spanish industries. Journal of Banking and Finance 2000; 24; 985-1004.

Coelli T. A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program. CEPA Working Paper 1996/08, available at: http://www.une.edu.au/econometrics/cepa.htm; 1996.

Drake L. Efficiency and productivity change in UK banking. Applied Financial Economics 2001; 11; 557-571.

Fries S, Taci A. Cost efficiency of banks in transition: Evidence from 289 banks in 15-post communist countries. Journal of Banking and Finance 2005; 29; 55-81.

Girardone C, Nankervis J.C, Velentza E-F. Efficiency, Ownership and Financial Structure in European Banking: A cross-country comparison. Discussion Paper No. 06-06, University of Essex: UK; 2006.

Goddard J.A, Molyneux P, Wilson J.O.S. European Banking: Efficiency, Technology and Growth, John Wiley & Sons Ltd: Chichester; 2001.

Halkos G.E, Salamouris D.S. Efficiency measurement of the Greek commercial banks with the use of financial ratios: a data envelopment analysis approach. Management Accounting Research 2004; 15; 201-224.

Hauner D. Explaining efficiency differences among large German and Austrian banks. Applied Economics 2005; 37; 969-980.

Havrylchyk O. Efficiency of the Polish banking industry: Foreign versus domestic banks. Journal of Banking and Finance 2006; 30; 1975-1996.

Isik I, Hassan M.K. Technical, scale and allocative efficiencies of Turkish banking industry. Journal of Banking and Finance 2002; 26; 719-766.

Isik I., Hassan M.K. Efficiency, Ownership and Market Structure, Corporate Control and Governance in the Turiksh Banking Industry. Journal of Business Finance and Accounting 2003; 30; 1363-1421.

Kamberoglou N.C., Liapis E., Simigiannis G.T., Tzamourani P. Cost efficiency in Greek Banking. Working Paper No. 9, January, Bank of Greece; 2004.

Karafolas S, Mantakas G. A note on cost structure and economies of scale in Greek banking. Journal of Banking and Finance 1996; 20; 377-387.

Kolari J, Zardkoohi A. Economies of Scale and Scope in Thrift Institutions: The Case of Finnish Cooperative and Savings Banks. Scandinavian Journal of Economics 1990; 92; 437-451.

Lang G, Welzel P. Efficiency and technical progress in banking: empirical results for a panel of German cooperative banks. Journal of Banking and Finance; 20; 1003-23.

Lozano-Vivas A, Pastor J.T, Pastor J.M. An Efficiency Comparison of European Banking Systems Operating under Different Environmental Conditions. Journal of Productivity Analysis 2002; 18; 59-77.

Luo X. Evaluating the profitability and marketability efficiency of large banks. An application of data envelopment analysis. Journal of Business Research 2003; 56; 627-635.

Maudos J, Pastor J.M, Perez F. Competition and efficiency in the Spanish banking sector, the importance of specialization. Applied Financial Economics 2002; 12; 505-516.

Molyneux P, Williams J. The Productivity of European Co-operative Banks. Managerial Finance 2005; 31; 26-35.

Neal P. X-Efficiency and Productivity Change in Australian Banking. Australian Economic Papers 2004; 43; 174-191.

Noulas A.G. Deregulation and Operating Efficiency: The Case of the Greek Banks. Managerial Finance 2001; 27; 35-47.

Noulas A.G. Productivity growth in the Hellenic banking industry: state versus private banks. Applied Financial Economics 1997; 7; 223-228.

Pasiouras F. Estimating the technical and scale efficiency of Greek commercial banks: the impact of credit risk, off-balance sheet activities, and international operations, Working Paper, School of Management, University of Bath, available at: http://www.bath.ac.uk/management/research/papers.html; 2006.

Pasiouras F. International evidence on the impact of regulations and supervision on banks' efficiency: an application of two-stage data envelopment analysis. Review of Quantitative Finance & Accounting 2007; Forthcoming.

Pastor J.M. Credit risk and efficiency in the European banking system: A three-stage analysis. Applied Financial Economics 2002; 12; 895-911.

Rezitis A.N. Productivity growth in the Greek banking industry: A non-parametric approach. Journal of Applied Economics 2006; IX; 119-138.

Rezvanian R, Mahdian S, Elyasiani E. Economics of scale and scope in small depository institutions: Evidence from U.S. cooperative banks. The Quarterly Review of Economics and Finance 1996; 36; 39-54.

Saxonhouse G.R. Estimated Parameters as Dependent Variables. American Economic Review 1976; 66; 178-183.

Soteriou A.C, Zenios S.A. Using data envelopment analysis for costing bank products. European Journal of Operational Research 1999; 114; 234-24.

Tsionas E.G., Lolos S.E.G., Christopoulos D.K. The performance of the Greek banking system in view of the EMU: results from a non-parametric approach. Economic modelling 2003; 20; 571-592.

Weill L. Measuring Cost Efficiency in European Banking: A Comparison of Frontier Techniques. Journal of Productivity Analysis 2004; 21; 133-152.

Table 1- Aggregate market shares (%) of different types of credit institutions operating in Greece

	Assets			Loans			Deposits		
	2003	2004	2005	2003	2004	2005	2003	2004	2005
Commercial banks	82.1	80.9	81.2	84.5	85.1	84.9	82.6	81.8	80.5
Foreign banks	9.3	10.0	10.1	9.4	8.8	8.8	7.3	8.2	9.1
Co-operative banks	0.6	0.7	0.8	0.9	1.0	1.0	0.7	0.8	0.9
Specialized Credit Institutions[1]	8.0	8.4	7.9	5.2	5.1	5.3	9.4	9.2	9.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes: [1]Postal Savings Bank and Deposits & Loans Fund, Source: Bank of Greece Annual Report (2004, 2005)

Table 2 – Basic figures of Greek Co-operative banks 2000-2004

	2000	2001	2002	2003	2004	Average increase 2000-04
Assets	548.2	734.82	926.09	1,244.74	1,593.49	30.61%
Loans	383.28	530.36	721.43	956.03	1,270.08	34.94%
Deposits	324.56	491.00	682.08	975.76	1,272.41	40.91%
Equity capital	196.70	204.65	214.81	233.48	264.60	7.65%
Cooperative capital	132.03	139.79	145.69	151.04	165.68	9.69%
Gross profit	34.95	38.21	47.28	60.91	76.75	26.01%
Net profit before taxes	15.45	13.87	17.61	24.16	28.82	19.29%
Branches	48	59	72	96	112	16.67%
Personnel	380	487	568	683	762	11.57%
Members	88,475	101,370	114,670	129,577	144,176	11.27%

Source: Association of Greek Co-operative Banks (2005)

Table 3 – Descriptive statistics (mean and standard deviation)

Panel A: DEA Inputs & Outputs								
	Y1	Y2	X1	X2	X3	P1	P2	P3
Mean	58,201	3,462	1,514	51,030	38.795	0.251	0.038	20.293
St dev	101,090	5,863	2,423	94,782	54.858	0.137	0.021	4.683
Panel B: Tobit regression Independent variables								
	EQAS	LOGAS	BRANCHES	ATMS	GDPCAP	UNEMPL	INCOME	INVGDP
Mean	0.278	4.530	4.493	3.556	13,610	10.873	0.053	0.301
St dev	0.094	0.411	5.116	7.616	3,291	2.239	0.029	0.052

Notes: Y1: loans, Y2: liquid assets & investments, X1: fixed assets, X2: deposits, X3: number of employees, P1: depreciation expenses/fixed assets, P2: interest expenses /deposits, P3: personnel expenses/number of employees; EQAS: equity to total assets, LOGAS: logarithm of total assets; BRANCHES: number of branches, ATMS: number of ATMs; GDPCAP: GDP per capita, UNEMPL: unemployment rate, INCOME: disposal income of households in the region as a percentage of the total disposal income of households in Greece; INVGDP: total gross fixed capital formation as a percentage of GDP in the same geographical area; All statistics in Panel B are after replacing observations above the 95th percentile and below the 5th percentile with the corresponding values. This approach reduces the impact of outliers in the estimation of the parameters of the model while it allows retaining all observatories in sample.

Table 4 – Average efficiency scores by year

Year	No. of banks	TE	AE	CE
2000	14	0.938	0.886	0.832
2001	14	0.912	0.898	0.820
2002	14	0.914	0.911	0.836
2003	15	0.927	0.883	0.823
2004	16	0.915	0.877	0.802
Mean (2000-04)		0.921	0.891	0.823

Notes: TE: technical efficiency, AE: scale efficiency, CE: cost efficiency

Table 5 – Tobit regression results

Panel A: Efficiency scores regressed over bank-specific attributes			
	TE	AE	CE
EQAS	0.688***	-0.210	0.108
	(3.012)	(-1.064)	(0.422)
LOGAS	0.171*	0.170**	0.250**
	(1.713)	(2.089)	(2.542)
BRANCHES	-0.030***	-0.013	-0.034***
	(-2.855)	(-1.532)	(-2.581)
ATMS	0.011**	0.002	0.012*
	(2.429)	(0.609)	(1.759)
Constant	0.091	0.243	-0.218
	(0.199)	(0.660)	(-0.485)

Panel B: Efficiency scores regressed over bank-specific attributes & market conditions			
	TE	AE	CE
EQAS	0.617***	-0.186	0.117
	(2.639)	(-1.210)	(0.590)
LOGAS	0.187*	0.201***	0.297***
	(1.871)	(3.043)	(3.762)
BRANCHES	-0.026**	-0.002	-0.020
	(-2.545)	(-0.156)	(-1.568)
ATMS	0.008*	-0.003	0.004
	(1.796)	(-0.509)	(0.603)
GDPCAP	-8.53E-06*	-2.03E-05***	-2.47E-05***
	(-1.735)	(-3.830)	(-3.997)
UNEMPL	-0.020***	-0.008	-0.018**
	(-2.895)	(-0.934)	(-2.083)
INCOME	0.836	1.119**	1.437**
	(1.020)	(2.346)	(2.390)
INVGDP	-0.227	-0.364	-0.361
	(-0.753)	(-1.180)	(-0.996)
Constant	0.389	0.474	0.098
	(0.873)	(1.528)	(0.270)

Notes: t-values in parenthesis, ***Statistically significant at the 1% level, ** Statistically significant at the 5% level, * Statistically significant at the 10% level; TE: technical efficiency, AE: allocative efficiency, CE: cost efficiency; EQAS: equity to total assets, LOGAS: logarithm of total assets; BRANCHES: number of branches, ATMS: number of ATMs; GDPCAP: GDP per capita, UNEMPL: unemployment rate, INCOME: disposal income of households in the region as a percentage of the total disposal income of households in Greece; INVGDP: total gross fixed capital formation as a percentage of GDP in the same geographical area; QML (Huber/White) standard errors and covariates have been calculated to control for heteroscedacity

University of Bath School of Management
Working Paper Series

School of Management
Claverton Down
Bath
BA2 7AY
United Kingdom
Tel: +44 1225 826742
Fax: +44 1225 826473
http://www.bath.ac.uk/management/research/papers.htm

2006		
2006.01	Neil Allan and Louise Beer	Strategic Risk: It's all in your head
2006.02	Richard Fairchild	Does Auditor Retention increase Managerial Fraud? - The Effects of Auditor Ability and Auditor Empathy.
2006.03	Richard Fairchild	Patents and innovation - the effect of monopoly protection, competitive spillovers and sympathetic collaboration.
2006.04	Paul A. Grout and Anna Zalewska	Profitability Measures and Competition Law
2006.05	Steven McGuire	The United States, Japan and the Aerospace Industry: technological change in the shaping of a political relationship
2006.06	Richard Fairchild & Yiyuan Mai	The Strength of the Legal System, Empathetic Cooperation, and the Optimality of Strong or Weak Venture Capital Contracts
2006.07	Susanna Xin Xu, Joe Nandhakumar and Christine Harland	Enacting E-relations with Ancient Chinese Military Stratagems
2006.08	Gastón Fornés and Guillermo Cardoza	Spanish companies in Latin America: a winding road
2006.09	Paul Goodwin, Robert Fildes, Michael Lawrence and Konstantinos Nikolopoulos	The process of using a forecasting support system

2006.10	Jing-Lin Duanmu	An Integrated Approach to Ownership Choices of MNEs in China: A Case Study of Wuxi 1978-2004
2006.11	J.Robert Branston and James R. Wilson	Transmitting Democracy: A Strategic Failure Analysis of Broadcasting and the BBC
2006.12	Louise Knight & Annie Pye	Multiple Meanings of ‘Network’: some implications for interorganizational theory and research practice
2006.13	Svenja Tams	Self-directed Social Learning: The Role of Individual Differences
2006.14	Svenja Tams	Constructing Self-Efficacy at Work: A Person-Centered Perspective
2006.15	Robert Heath, David Brandt & Agnes Nairn	Brand relationships: strengthened by emotion, weakened by attention
2006.16	Yoonhee Tina Chang	Role of Non-Performing Loans (NPLs) and Capital Adequacy in Banking Structure and Competition
2006.17	Fotios Pasiouras	Estimating the technical and scale efficiency of Greek commercial banks: the impact of credit risk, off-balance sheet activities, and international operations
2006.18	Eleanor Lohr	Establishing the validity and legitimacy of love as a living standard of judgment through researching the relation of being and doing in the inquiry, 'How can love improve my practice?’
2006.19	Fotios Pasiouras, Chrysovalantis Gaganis & Constantin Zopounidis	Regulations, supervision approaches and acquisition likelihood in the Asian banking industry
2006.20	Robert Fildes, Paul Goodwin, Michael Lawrence & Kostas Nikolopoulos	Producing more efficient demand forecasts